CPDLC Procedures

The goal of this memo is to document procedures for the handoff and transfer of communication using CPDLC for both by the NASA CE-6 AOL and fast-time modeling teams.

The following information has been provided to me by Gerald Smith at the Miami Center and Randy Sollenberger at the FAA Tech Center.

CPDLC transfer of communication

There are 3 modes of operation of the CPDLC transfer of communication (TOC).

1. Turned off – in this mode, CPDLC TOC is disabled and voice calls must be used as in today's operations ("TOC off" is displayed at the top of the scope)

2. Manual – in this mode, the automation constructs the message and holds it in the status list until the controller manually sends it. ("TOC man" is displayed at the top of the scope)

3. Automatic – in this mode, the automation constructs the CPDLC TOC message and sends it the instant the receiving controller accepts the handoff ("TOC auto" is displayed at the top of the scope)

For manual and automatic modes, an adaptation in HOST determines the voice frequency of the receiving sector (i.e., the sector that the aircraft will be entering next) and inserts it into the message. In addition:

- If the receiving sector is CPDLC-equipped and the receiving sector has CPDLC **enabled** (i.e., either manual or automatic mode), then the TOC message also tells the aircraft to **monitor** (i.e., pilot call-in **not required**) the assigned voice frequency.

- If the receiving sector is CPDLC-equipped, but CPDLC is **turned off** or the receiving sector is **not equipped** with CPDLC, then the TOC message also tells the aircraft to **contact** (i.e., pilot call-in **required**) the sector via the assigned voice frequency.

There is a diamond symbol in the flight data block (FDB) of each aircraft. If the symbol is filled solid, this means that the controller has access to that aircraft via CPDLC. If the symbol is unfilled, this means that another sector (most likely an adjacent sector) has access to that aircraft via CPDLC. Thus, it is impossible for two adjacent sectors to both have the same aircraft displayed with a filled diamond in the FDB. Whether the controller has access to the aircraft via voice frequency is dependent on whether or not the aircraft has properly tuned into the correct frequency. If a lightning bolt symbol is displayed instead of the diamond (as would be the case when the TOC message is being sent to an aircraft), this means that the system is in the process of changing which sector

has access to the aircraft via CPDLC. The lightning bolt symbol is displayed for very short periods of time.

Handoff with CPDCL

In both today's operations and in a CPDLC environment, a handoff (i.e., transfer of control) can be initiated either by the transferring controller or the automation. An "automated handoff" puts a portion of the FDB in a flashing state. This is a visual cue to the receiving controller that he/she may now accept control authority for the aircraft. Depending on which method is used to put the aircraft in a "flash state" determines the CPDLC mode of TOC. (Note that handoffs performed the old-fashion way – by the transferring controller using the interphone to call the receiving controller – are often referred to as manual handoffs, but they should not be confused with the manual handoff discussed below)

Manual handoff (controller-initiated automated handoff)

The transferring controller can use the trackball or computer readout device (CRD) to initiate the handoff. If a manual handoff is used and the CPDLC TOC mode is set to automatic, then the system will use the automatic TOC when the receiving controller accepts the handoff. This is referred to as **"manual handoff/auto TOC"**. This results in the handoff and the TOC being nearly simultaneous, which is certainly advantageous. If the CPDLC TOC mode is set to manual, the transferring controller will still have to manually send the TOC message when the receiving controller accepts the handoff. This is referred to as **manual handoff/manual TOC** and is the most workload-intensive method for using CPDLC for handoffs.

Automated handoff (computer-initiated automated handoff)

The other option for the controller is to use automated handoffs. In this method, the automation puts the aircraft in the flash state when the aircraft approaches the boundary of the receiving sector. When the receiving controller accepts an automated handoff, the CDPLC TOC mode of operation reverts to "manual TOC" for the transferring controller *even if the automatic mode is selected*. This is referred to as **"auto handoff/manual TOC"**. The auto handoff/manual TOC ensures that the transferring controller is given the opportunity to confirm the TOC so that an aircraft cannot leave a sector without his/her awareness. In this manner, errors of omission are prevented.

"Manual handoff/auto TOC" vs. "auto handoff/manual TOC"

There was a deliberate decision by the FAA to inhibit an "auto handoff/auto TOC" situation with CPDLC for reasons mentioned in the previous paragraph. The "manual handoff/auto TOC" is the preferred method since, in terms of task time, the manual handoff is faster than manual TOC. Although the difference in task time is small, handoffs are done on a frequent basis so the reduction in workload is measurable. In addition, manual handoff/auto TOC allows the transferring controller to be in charge of deciding when he/she is really finished with an aircraft. On the other hand, the final transferring controller action for auto handoff/manual TOC is dependent on an action by the receiving controller. As such, the transferring controller will have to continuously monitor for the receiving controller's acceptance of the handoff.

At the Miami Center, a majority of the controllers are currently using the auto handoff/manual TOC mode of operation despite the arguments mentioned in the previous paragraph. The reason for this is that right now the number of CPDLC-equipped aircraft is few so that the workload impact is not very significant. Furthermore, the controllers are more comfortable with the manual TOC mode. Certainly for the timeframe of CE-6, the high level of CPDLC-equipped aircraft should warrant the use of the automatic TOC mode.

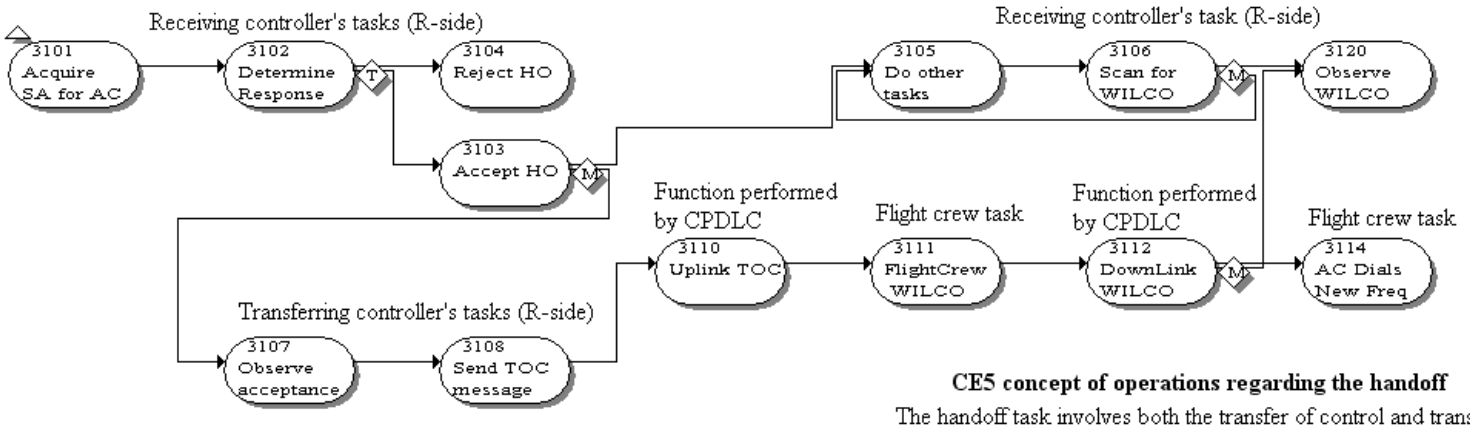
Note that in either method, the receiving controller must always accept (i.e., take) the handoff **manually** – accepting handoffs can never be automated because of the need to acquire situation awareness about all incoming aircraft.

Attached are the task networks for the manual handoff/auto TOC. Note that the task time for task 3108 is set to zero since the automation is assumed to be performing this task even though text description says it's a "transferring controller" task. I just realized that I didn't update the text description to reflect what the model is doing. All the transferring controller has to do in that task network is observe that the handoff has been accepted by the receiving controller.

Network 3100 Receive Handoff

Handoff Task Using CPDLC

(Applies to pre-DAG baseline, CE6, CE6 variant, and CE5 "managed" aircraft. Assumes CPDLC Spiral Stage 1.)



CPDLC provides two options in the data link message during handoffs:

1) Request the flight crew to "monitor" assigned voice frequency
2) Request the flight crew to "contact" the receiving controller on the assigned voice frequency

The 2nd option is used when a sector that is CPDLC-equipped is adjacent to a sector that is not equipped with CPDLC. In this model, all sectors are assumed to be CPDLC-equipped so only the 1st option is used.

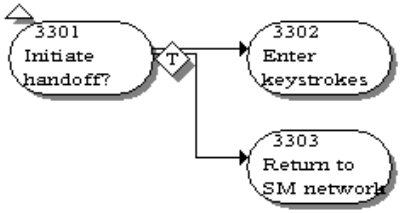
CE5 concept of operations regarding the handoff

The handoff task involves both the transfer of control and transfer of communication for managed (non-equipped) aircraft. On the other hand, for CE5 autonomous aircraft, the transfer of control between controllers in adjacent sectors is superflous because the aircraft are responsible for their own self-separation and meeting TFM restrictions. Given this, the CE5 Conops was modified to state that the the transfer of communication (voice frequency change) would be performed by ground automation that would automatically uplink the radio frequency of the next sector at the appropriate time. The benefit to this approach is that no actions are needed by the controller when a CE5 autonomous aircraft transitions from one sector to the next.

Network 3300 Initiate Handoff

Initiate Handoff Task

(Applies to pre-DAG baseline, CE6, CE6 variant, and CE5 "managed" aircraft. Assumes CPDLC Spiral Stage 1.)



For CPDLC, the transferring controller initiates the handoff manually to inhibit the aircraft from changing radio frequency without a proactive action by the transferring controller.